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Contribution from the Forest Service, Henry S. Graves, Forester.
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AN ECONOMIC STUDY OF ACACIAS.

By Charles Howard Shinn,
Forest Examiner.

PURPOSE OF THE STUDY.

The acacias are so valuable as a source of tanning material and of timber, and are so well adapted to the reclamation of sandy and semi-desert lands that the introduction and culture of these exotics into certain portions of the United States may prove extremely profitable.

To a certain extent parallels exist between the culture, in America, of eucalypts and acacias. Both were introduced in California about the same time, and both have thrived there. Commercially, too, their ranges are practically identical, though acacias do not make as large demand upon the soil. In both cases, however, the lack of frost hardiness limits their range.

The aim of this bulletin is to call attention to the economic importance of the leading acacias with the idea of bringing about more general planting.

THE GENUS ACACIA.

ITS EXTENT.

The acacias form the most characteristic group in the suborder Mimoseæ, of the great bean family Leguminosæ, represented in the United States by such trees as black locust (*Robinia pseudacacia*), honey locust (*Gleditsia triacanthos*), coffee tree (*Gymnocladus dioicus*), and redbud (*Cercis canadensis*). They are, in the main, natives of Australia, which has about 300 species. There are 150 other species scattered over the world, principally in Asia, Africa, and America, with one important species, the koa, in the Hawaiian Islands. Of the 450 not more than 75 have a known economic value, and not more than 50 are in general cultivation, though 150 species are growing in nurseries, gardens, and arboretums in the United States. A compilation of California nursery catalogues made in 1911 showed 103 species listed. The authorities of Golden Gate Park, San Francisco, enumerate 60 species growing within the park.

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Besides the 450 species there are many varieties developed through cultivation. Further, much confusion exists as to the proper identification, not only of the acacias but of closely related genera, which are sometimes confused with the true acacias. An example of this is found in the so-called *Acacia lophantha*, which is an albizzia, as is the pink-flowered "Constantinople acacia." The flowers of the true acacias are usually yellow, and are produced in globose heads variously arranged; those of the albizzias are generally borne as spikes, similar to those of the Australian "bottle brush" (*Melaleucas*), and are seldom yellow, though some are a greenish white.

NOMENCLATURE.

The difficulties of identification have led to equal difficulties of nomenclature, or, rather, the confusion in either case has led to confusion in the other. Except for the species of greatest economic value, which have been longest in cultivation, the nomenclature is so mixed in California that acacias are still being sent to Dr. Maiden, director of the Sydney Botanic Garden, for identification.

Mr. Ernest Braunton, of Los Angeles, has done much in recent years to secure the correct identification of the acacias planted for ornament in southern California. Dr. Franceschi and Mr. P. Reidel, of Santa Barbara, and Miss Katherine Jones, of the University of California, at Berkeley, have worked with the acacias to the end that the synonyms may be all weeded out, and that the various species grown in California, where acacias have been most extensively planted in this country, may be accurately known.

The chief difficulty has been with the so-called *decurrens* group, and the problem has been to distinguish between species and mere varieties.

The classification made by Dr. J. H. Maiden[1] seems to be both culturally and scientifically correct, and its general adoption offers the best escape from present confusion in American nomenclature. According to this (1) *Acacia decurrens*, or *decurrens* var. *normalis* (Willd. and Benth.), is the "black wattle"; (2) *Acacia decurrens* var. *mollis* (Benth.) is the *Acacia mollissima* (Willd.), and is the leading "green wattle"; (3) *Acacia decurrens* var. *pauciglandulosa* (F. von M.) also is known usually as "green wattle"; (4) *Acacia decurrens* var. *dealbata* (F. von M.) is the leading "silver wattle."

These four wattles and two or three others of lesser importance pass into each other by successive gradations. They show cultural differences, however, and marked variations in yield of tan bark. The nurseryman naturally chooses the more floriferous and shapely form of *Acacia decurrens*, but the commercial planter must consider bark yields and proportion of tannin.

[1] "Wattles and Wattle Barks," third edition, pp. 103, Sydney, 1906.

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CHARACTERISTICS OF VARIOUS SPECIES.

SOIL AND MOISTURE REQUIREMENTS.

Acacias form one of the most conspicuous associations of all those which group themselves close to deserts. While they do not constitute a true desert species, they nevertheless carry tree life well into the desert regions, becoming shrubby and scattered. In fact, some species, such as *Acacia greggi*, one of the most valuable lac-insect bearing species, will thrive with only 3 inches of rainfall; some grow on inland sand dunes far from ocean influences. With a few notable exceptions, the acacias are preeminently adapted to poor soil and rainless summers and to semiarid conditions, though most of them respond to good soil and abundant moisture. Their great drought-resisting qualities come from their deep, strong root systems and from their leaves, which are chiefly phyllodes, or flattened stems, with sensitive specialized powers of movement by which evaporation may be greatly lessened.

A light, warm, well-drained soil, if cultivated, will produce rapid growth, and the rich and heavy soils which some of the eucalypts demand for their best development are not necessary for the acacias. The most prominent exception to this is *Acacia melanoxylon*, or "black wood," which produces choice timber but has little value for tanning unless the tannic acid is concentrated by the extract method. This is a river-bottom species, associated with *Eucalyptus globulus* and other trees of that type.

Acacias readily adapt themselves to a heavier precipitation and more tropic conditions than characterize their native soil, as proved by many years of growth in the Hawaiian Islands and on the Natal coast of Africa. Indeed, many species, as with the eucalypts, when introduced elsewhere, may grow even more rapidly than in their native region. But mainly the significant fact about the tree, so far as moisture conditions are concerned, is that it does not require a heavy annual rainfall nor any summer rain. It is this characteristic which renders it valuable on the southern Pacific coast and in the Southwest. It must be kept in mind that the trees are only half hardy as regards frost, and will not endure a temperature below 16° F. or 20° where the cold is likely to be sustained.

So far as known, no other semitropic trees of high economic value possess to so great an extent the ability to thrive upon and to improve a great variety of arid and sterile soils. Through their agency large areas of land unfit for ordinary cultivation, and at present producing only a scanty pasturage at best, may be reclaimed and utilized. Recent discoveries in the nitrogen-fixing qualities of the legumes point to the possibility of a hitherto unrecognized value in acacia growing.

FORMS.

With so many and so varied species there can be no form and no rate of growth common to the whole genus. Some acacias are mere herbaceous plants; others are towering trees; most are shrubs, and some, in fact, are vines or climbers. In certain instances the same plant which has a creeping habit when exposed to cold salt winds on the seashore will be able, a little farther inland, to assume an erect form and, where still better protected, to become a fully developed tall tree. One authority describes these size variations thus:

> Some tiny species hardly exceed 3 or 4 inches in height, and may be crushed like the grass of the field. Most of them are shrubs, or trees of moderate size, while at least two species attain the stature of large forest trees, both of them being found to measure up to nearly 4 feet in diameter, while one has been found to attain a height of over 100 feet, and the other the extraordinary height of 150 feet.[1]

The largest acacia is probably *Acacia bakeri*, of which specimens have been described as over 160 feet high, with a clear length of from 50 to 60 feet and diameters of from 2 to 4 feet. Other large trees are *Acacia melanoxylon*, *A. longifolia*, *A. dealbata*, and *A. decurrens*, all of which may attain a height of 100 feet or more. *A. salicina*, *A. excelsa*, *A. elata*, *A. prominens*, *A. pendula*, and *A. binervata* are also large trees, ranging from 30 to 80 feet in height.

Those which are most used for commercial products, and particularly for tannin, do not need to attain large size or great age before the products are merchantable. Thus they can be managed on a shorter rotation than most forest trees.

ENEMIES.

Insects.

The acacias first planted in California grew so fast, bloomed so soon and so freely, and were so free from disease that most horticulturists felt sure that acacias would become the most important shade trees for California. This enthusiasm was particularly marked from 1870 to 1876. It was like the subsequent fad in the Middle West for the hardy catalpa or the more recent furore over eucalypts in California. There followed, however, a sharp reaction because of the ravages of various scale insects, and many trees were cut down. But after the introduction of the vedalia, which destroyed the cottony cushion scale, and the adoption of the various sprays it was found that the acacias are not peculiarly subject to injury by scale insects, and are no more often a haven for the pests than are oaks, olives, and various orchard trees. The most dangerous insect enemy,

[1] J. H. Maiden, "Wattles and Wattle Barks," Government Printer, Sydney, New South Wales.

[2] For information on insects and methods for their control the reader should apply to the State Experiment Station, Berkeley, Cal., or to the Bureau of Entomology, United States Department of Agriculture, Washington, D. C.

according to various observations, is the cottony cushion scale (*Icerya purchasi*).

The scale insects have sucking mouthparts and subsist on the juices from the inside of the tree; for this reason they are hard to combat, because it is difficult to poison their food supply. Since they live upon the sap, they must necessarily lessen the vitality of a tree, especially where there is a very dry summer climate. If they are very numerous, trees can not thrive and may even be killed. Scale insects, besides robbing the tree of nourishment, harm the tissues, close the pores by their excretions, and supply conditions under which fungi may get a good start. All these are much less serious with the acacias than the actual loss of sap; and where the water supply is ample the actual harm done by the scale is very slight. But since one of the chief values of the acacias is their adaptability to very arid regions, the scale insects should be destroyed wherever they exist, and care should be taken to establish plantations from seed or from thoroughly disinfected plants.

Two insect enemies of the wattle in Natal, reported by Mr. David G. Fairchild, are a bag worm, which destroys great quantities of foliage and checks the growth of the trees, and a more destructive locust, which can retard growth to the equivalent of more than a year. The bag worms are collected and burned, and the plague of locusts is prevented by spreading poisoned molasses about their breeding places. A special locust expert is employed by the Natal Government; with his corps of laborers he poisons all the principal breeding places of the pest.

Other insects attack the black wattle (*Acacia decurrens*) in Australia.[1] Of these, one is an undescribed species of weevil (*Bruchus* sp.) which was found in seeds purchased in San Francisco, and presumably was introduced into California from Australia or South Africa in the seed. Another is a long-horned beetle (*Cyelle cricornis*) of almost world-wide distribution in the Tropics; several other insects do more or less harm.

Fire.

There seem to be various opinions about the fire-resistant qualities of acacias, though they are generally considered very sensitive to fire. Some authors have stated that they do not burn readily, and the wattles in particular have been recommended for planting as fire breaks, not so much because they are not easily ignited but because their growth is so dense, both above and below ground, that no ground cover can thrive, and there is, therefore, beneath the trees an area free of vegetation. On the other hand, Dr. Maiden says[2]

[1] "The Black Wattle," by Jared G. Smith, Bulletin No. 11, Hawaii Agricultural Experiment Station.
[2] "Wattles and Wattle Barks," Sydney, 1906.

that wattle plantations must be protected from fire by fire breaks "and also by the removal of the inflammable brush from among them. At the same time, the finely divided foliage of *Acacia decurrens* makes it the most susceptible of the commercial wattles to destruction by fire." In Natal, according to Mr. David G. Fairchild—[1]

> The greatest enemy of the wattle is the grass fire. From the surrounding prairie such fires spread into the plantations and destroy them. To prevent this, nearly 50 miles of fire breaks, made by planting broad strips of prairie, have been constructed about the forests, and the expense of this adds materially to the original cost of establishing a wattle estate.

Another author, writing from the Transvaal,[2] calls attention to the prevailing notion that "it is commonly supposed that wattles a few years old are safe from fire, and in fact make good fire breaks. This, however, is not the case, and many disastrous fires have entirely destroyed wattle plantations." A fire which merely defoliated the trees scorched the bark and rendered it valueless. "From this it will be seen how very necessary it is to protect the plantations from fire as far as possible. This can best be done by plowing or burning wide belts around the trees," and by dividing the plantation into blocks by means of roads, which must be kept clean.

Other Injuries.

Frost is, of course, to be avoided, though many species will stand temperatures of 20° F. if not too prolonged. Hail may do considerable damage by bruising the bark and breaking off shoots. Crooked stems and branches have resulted from hail injury.

A black-wattle plantation in Hawaii suffered a loss of 20 per cent due to three causes—from being overmature, from stock browsing, and from insect enemies. Goats are particularly injurious, and their severe cropping will altogether destroy growth.

HISTORY OF ACACIA CULTURE IN CALIFORNIA.

Those who first planted acacias in California obtained only the species which had been planted on the Atlantic coast and in the Middle West. Many of these species were not in the least adapted to the California climate. It was then suggested that since western Mexico, Chile, and southern Europe had climates similar to that of California, acacias from these regions would be suitable, but introduction was slow and difficult. The Spanish settlements had furnished a few

[1] Bulletin 51, Bureau of Plant Industry, Miscellaneous Papers, "The Cultivation of the Australian Wattle," pp. 21–25.

[2] Lionel E. Taylor, Assistant Conservator of Forests, in Forestry Section of Transvaal Agricultural Journal, Jan., 1910, vol. 8, No. 30, Agricultural Department, Pretoria.

species which were extensively propagated, and one of them, *Acacia farnesiana*, familiar about the missions of San Diego and Santa Barbara, was grown by nurserymen in San Francisco, Los Angeles, and Sacramento as early as 1854. Potted acacias and acacia flowers, grown at Sacramento, were exhibited at one of the first agricultural fairs held in California, in 1855. An Australian acacia bloomed at Marysville before 1860.

The importation of acacia seed from Australia began in a curious way. A few of the Australians who came to California at the time of the gold fever brought over seeds and rooted plants and sold them to the nurserymen at high prices. By 1853 Col. Warren, who had established the California Farmer, was obtaining Australian seeds from these immigrants, and was soon importing direct from Sydney. In 1854 he was advertising acacia seed, and nurserymen in the vicinity of San Francisco were planting *Acacia decurrens* and *Acacia melanoxylon*. These two species were the pioneers of the Australian acacias in California. Acacias from these early importations were blooming and attracting attention in San Francisco, San Jose, and Sacramento by 1858.

By 1862 the late Julius Forrer, a German, for a long time the capable foreman of one of the University of California experiment stations, was growing in his nursery in San Francisco these species: *Acacia cyanophylla, A. cuneata, A. dealbata, A. homalophylla, A. linearis, A. longifolia A. lunata, A. melanoxylon, A. "mollissima"* (*A. decurrens* var. *mollissima*), *A. pendula*, and *A. receana*.

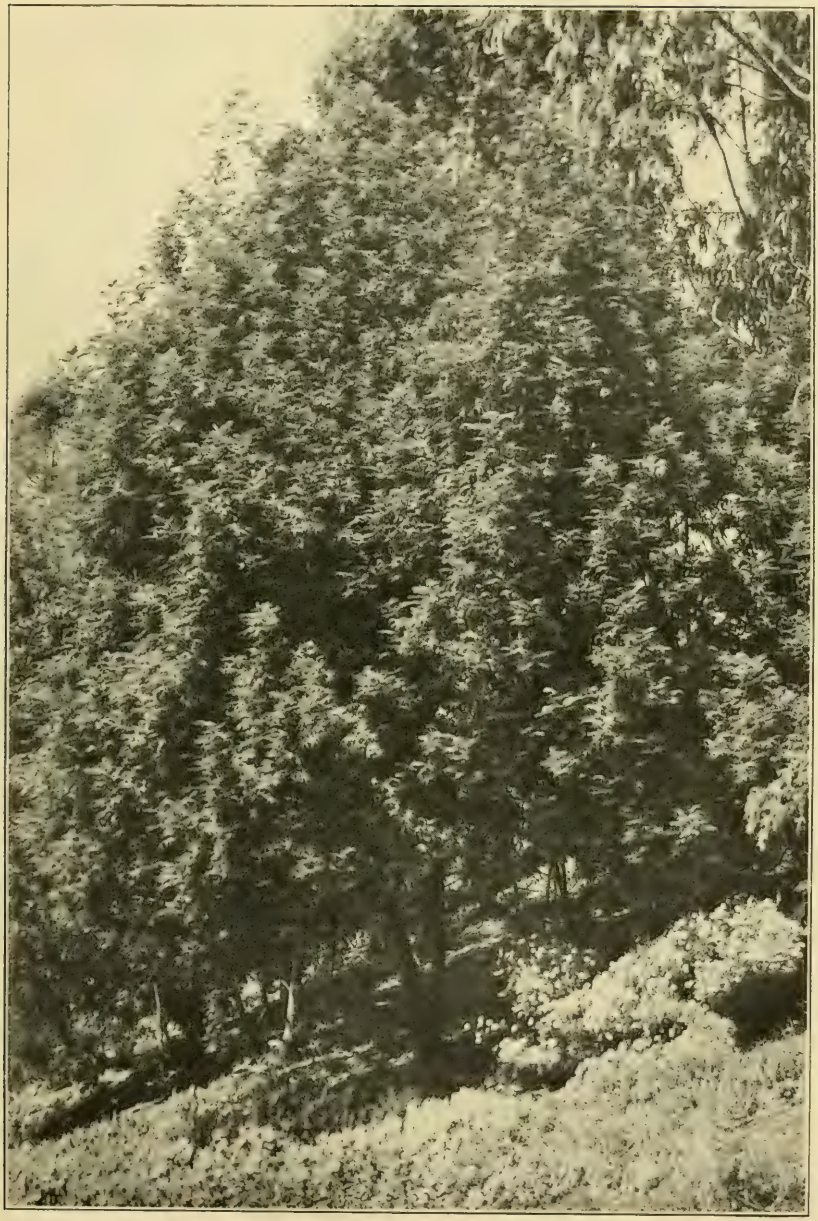
Between 1870 and 1875 enthusiam in acacia planting was at a high pitch. This was followed by a sudden reaction due to the introduction and depredations of scale insects. Since 1880, however, California nurserymen have increased their stock of acacias, and since 1900 sales have been much greater, especially in southern California, where some growers make a specialty of it. Mr. Wolleb, another German, of Fruitvale, Alameda County, bought trees from Forrer's nursery from 1862 to 1870 and tested many other species. In 1882 he published in the Rural Press a review of his experiments. He had tested *Acacia armata, argyrofolia, binervata, celestrifolia, cultriformis, cyanophylla, dentifera, discolor, farnesiana, extensa, pulchella, latifolia, saligna, linearis, longifolia, lunata, nigricans, nerifolia, receana, suavolens, verticillata, vestata*, and some others now dropped from cultivation.

Other Californians besides Mr. Wolleb made collections of acacias before 1880 and kept notes on their growth. The late Gen. John Bidwell planted some in Chico, Butte County, in the Sacramento Valley, and they are now magnificent specimens. A few were set out in Shasta City, about 200 miles north of San Francisco, and still flourish.

Mr. Alvinza Hayward, Mr. P. Nolan, and Mr. H. P. Livermore planted them extensively in Alameda County; J. de Barth Shorb made a 10-acre plantation in Los Angeles County about 1875. This plot has since been cut up into city lots, but some of the original trees remain.

The College of Agriculture of the University of California and the State Forestry Commission grew and distributed many acacias, and have published the results of successful investigations. The collection of acacias at Berkeley, the seat of the State university, was begun in 1872 with 30 species, and was subsequently augmented by many others. Parts of the arboretum were destroyed, however, to make way for new buildings. Acacias were planted at Chico and Santa Monica forestry stations, and at the latter place tannin determinations of the bark have been made. Acacia planting in Golden Gate Park, San Francisco, was begun by Mr. W. H. Hall, the superintendent, in November, 1870, when 1,200 acacias of 10 species were set out. Planting went on year after year under the supervision of the manager, Mr. John McLaren. In 1880 and 1889, 50,000 acacias were planted in the sands toward the western end of the park. In the years 1889 to 1892 not less than 50,000 trees, and usually 60,000 trees, were set out in a season, and in subsequent years from 5,000 to 20,000 were used each year, so that up to the present time about half a million have been planted. The Golden Gate Park nurseries still grow about 25,000 specimens every year, and they have more acacias and more kinds of acacias than anywhere else on the Pacific coast. This Golden Gate Park planting is such a remarkable example of sand-dune reclamation that it will be treated alone in a chapter devoted to that subject.

This review of acacia planting in California since 1852 shows that the field has been very fairly covered. Any person who desires to know whether a given species of acacia will thrive in any part of California is likely to find mature specimens within a reasonable distance. He may not find commercial or profit-yielding plantations, but he will find ample evidence of the adaptability of the tree to the soil and climate. Just as the olive and orange trees of the missions proved the suitability of the region to olive and orange groves, the many acacia trees, over a much wider range of country, show the commercial possibility of acacia plantations. The hardier acacias will flourish where the orange and olive will succeed. Nevertheless, many species have not yet been fully tested, and there is need of further systematic determination of the frost and drought limits, even of long-cultivated species; also for exact tests of bark yields and proportion of tannin. The naturalization of any exotic on a large scale requires much patience and money and involves complex problems.



A PLANTATION OF ACACIA DECURRENS MOLLIS IN GOLDEN GATE PARK, SAN FRANCISCO.

ACACIA ARABICA, ONE OF THE SOURCES OF GUM ARABIC, AT THE SANTA MONICA FOREST STATION, CALIFORNIA.

FIG. 1.—THICKETS OF ALBIZZIA LOPHANTHA NEAR THE OCEAN, GOLDEN GATE PARK, SAN FRANCISCO.

FIG. 2.—THICKETS OF ACACIA LONGIFOLIA ALMOST AT THE EDGE OF THE TIDE, GOLDEN GATE PARK.

The plant with the finer foliage is the acacia.

ECONOMIC USES.

The acacias were first spread abroad over the semitropic regions of the earth by reason of their easy culture, their adaptibility to many situations, and their attractiveness as shrubs or shade trees. Their wide range of economic uses, however, was very slowly recognized outside of Australia, where many species have long ranked with the eucalypts as profit-yielding trees. Some acacias have a remarkable value for the reclamation of sand dunes, whether they are seashore drifts or inland barrens. Many species furnish tanbark; others yield forage; others produce timber of notable quality; almost all are suited to ornamental plantings, and many are excellent for street trees and for shelter belts, and several furnish many special products of great economic value. In fact, various species of Australian acacias, according to Dr. Maiden, yield food, forage, medicine, fibers, gums, resins, kinos, perfumes, dyes, tannins (33 Australian species furnish tannin in commercial quantities), timbers, and ornamental finishing woods (at least 50 Australian species furnish valuable wood). Many Indian and African species furnish timber, gums, tanbark, catechu, and other products, and furnish host plants for the valuable lac insect (*Tachardia lacca*). The American *Acacia greggi* also furnishes lac. *A. farnesiana*, which is found in both the New and the Old World, is the famous "popinac" or "cassie" perfume plant so largely grown around Grasse in France.

Thus the farmer, the lumberman, the furniture maker, the stock raiser, the tanner, the perfumer, the chemist, and many others are interested in acacias, and the more useful species are properly recognized as being worthy of establishment over large areas, and of management on principles of forestry. The recognition of this fact has been notable during the last 10 years, because the best species of acacias are rapidly disappearing from their native countries, except where they have been intelligently protected and planted; and, further, because so many countries have successfully introduced acacia culture.

ACACIAS FOR SAND-DUNE RECLAMATION.

The acacias have great value as a ground cover, for dunes near the ocean, and for inland sand barrens, almost to desert conditions, since they will thrive with only a few inches of rainfall, provided it comes at such a time that the seeds can become rooted, and provided the temperature does not fall below 20° F. Where the average rainfall is not less than 20 inches and the summers are cool and the winters mild, almost any trees can grow if they get a start; what is needed in the first place, therefore, is some growth which will hold the drifting sands, binding them until a more stable soil, with some humus, is formed, and paving the way for valuable trees. This need is supplied by acacias.

Almost all west coasts present similar problems, not essentially different from those which have been successfully solved by Bremontier in France, and by Reventlot in Denmark.

The California dunes, the French *landes*, the Dutch *polders*, the Danish heaths, and the barrens of the Baltic coast of Prussia are all in the same category. Abroad the abundant use of the sea reed *Ammophila arenaria* is of first importance; but in the warmer regions of the globe the acacias can always follow the grasses. In some instances, if the acacias are freely used, they may entirely obviate the need for the preliminary grasses. In these warmer climates the low-growing acacias are much preferable to the broom and gorse so useful in more northern latitudes, while the larger acacias grow much faster than most other trees.

Abroad.

Africa.

The experience of several countries with acacia plantations near the shore emphasizes their desirability on such soils.

Cape of Good Hope.—The official reports of the conservator of forests, Cape of Good Hope Colony, South Africa, gives the results of extensive reclamation of sandy regions near the shore. For nearly 30 years these "blue books" have been crowded with information of interest to those who have to deal with the problem of fixing sands.

While acacias were first grown in South Africa for tanbark, firewood, and other uses, their value in making productive the enormous sand wastes was soon recognized. Such situations were extensively seeded, sometimes with acacias alone, and sometimes in combination with cluster pine (*Pinus pinaster*), the favorite conifer of the South African planter. The principal species were *Acacia leiophylla* Benth., (*Acacia saligna*, Wendl.), *Acacia longifolia* Willd., and *Acacia pycnantha* Benth., all of which yield tanbark, besides some of the larger wattles, such as *decurrens*, together with many of the lesser shrubby species. The climatic conditions are often more detrimental than those which prevail on the California sea coast, and the labor problem is certainly no more satisfactory.

Now that the plantations are well established, the seed from them and from other older plantations is gathered every year at small cost. In 1891 about 1,600 pounds of acacia seed were sown, or distributed to the public; the next year, 4,000 pounds, 1,963 of which were *A. leiophylla*. By 1898 the forest officers reported an annual sowing of 4,840 pounds of *A. leiophylla* seed and 4,360 of the shrubby *A. cyclops*. Summing up, not less than 20,000 pounds of acacia seed of various species were sown or distributed to planters in South Africa between 1888 and 1899.

Port Elizabeth.—In 1892, at Port Elizabeth, South Africa, 150 acres of drifting sands were reclaimed by the broadcast sowing of

A. leiophylla, *cyclops*, and *pycnantha*. Since the sand was very loose and fine, stakes interwoven with brush were first used to keep the sand from shifting, while the seeds were getting a start. The experiment was an entire success. The rainfall that year was about 16 inches. By 1896 more than 2,000 acres had been reclaimed at Port Elizabeth. In the choice of species it was planned that the smaller growth, such as *A. cyclops*, would bind the soil and enable the larger tanbark acacias to become established. During the South African war little was done to extend these plantations, but since then operations have steadily progressed.

The Port Elizabeth experiments demonstrated that broadcast sowing was not only feasible, but in this case seemed advisable. It costs from 4 to 6 cents a pound to gather acacia seeds from the bearing plantations. When the plantations were young the seed was drilled in at the rate of about 12 pounds to the acre. At this time, however, a much thinner sowing is usually considered better, and from 1 to 2 pounds only are sown to the acre, which would make the seed cost not more than 12 cents.

Port Jackson.—Acacias are being sown on drifting sands in South Africa in many other places besides Port Elizabeth, but the details of the planting are likely to vary with local conditions. At Port Jackson seed was sometimes sown in alternate rows with cluster pines, in some cases compartments or blocks of the plantation were entirely the one or the other. Again, rye or barley was sown thinly with the acacia or pine seed to give a quick binder and some shade. Ten years after planting the official report on these experiments states: "The sands have undoubtedly been fixed, and generally the trees have been doing well." The cost of these sowings ranged between $2.75 and $6 an acre. Wages were low, and it was practically all handwork, with but little use of labor-saving methods. The greatest expense was the filling in of gaps with nursery-grown plants, but this was seldom necessary.

ELSEWHERE.

Much additional evidence might be compiled from sand-binding in Natal, New Zealand, Australia, and the Mediterranean shores, but that which has been cited is sufficient to offer important suggestions for American practice. It has been conclusively proved that 16 inches of rainfall is ample; that it is an unnecessary expense to use nursery-grown plants; and that by using a mixture of shrubby and arborescent species, the larger tanbark and timber yielding trees can be started from the beginning of the operations. *Acacia cyclops* is valuable only for sand reclamation; the shrubby type of *A. longifolia* is quite as satisfactory. Even *A. longifolia* might be superseded by *A. leiophylla*, which resembles *A. cyanophylla;* it readily sends up shoots when cut down, and its bark contains from 30 to 35 per cent of tannin, which makes it a valuable commercial species. It is useful

also for firewood, as well as for fences and windbreaks. The *Acacia pycnantha* used in South Africa is the superb "golden" or broad-leaved wattle of South Australia, which yields one of the richest tanbarks in the world.

In California.

California has large areas of sand along the coast, more or less covered with beach plants, such as the abronias, lupins, and artemisias. Such sand areas have but little value, and have not improved in the past 50 years. These and similar areas in the Mojave region and the upper Salinas Valley can be readily reclaimed by the use of acacias, which can be selected not only for their sand-binding qualities but for their value as pasturage and as supplies of fuel wood and tannin. On such sand wastes the covering of shrubby acacias can be secured by sowing seed with the first rains in the fall. If the forage-yielding Australian "myalls" and "mulgas," such as *Acacia pendula*, *salicina*, and *aneura*, are chosen, they are likely to prove the most profitable crop that can be grown on such soils. *Albizzia lophantha* belongs with these as a shrub for browse. All of these species readily reproduce themselves, widening their extent along the seacoast, and will eventually produce a large amount of firewood.

As a matter of fact, acacias which have escaped from cultivation have become naturalized in many places along the California coast. There are thickets near the ocean between Watsonville and Santa Cruz, also near Morro, San Luis Obispo County, along the coast in Sonoma County, and likewise a few miles from Santa Monica. In a gulch near Carpinteria, south of Santa Barbara, there are self-sown seedlings and also large trees of *Acacia decurrens*, *melanoxylon*, and *longifolia*, which have grown from the stumps of older trees. Near old Ventura Mission there is the same adaptation of the Australian acacias to the California coast and foothills, even where they receive no care whatever.

In many cases the smaller acacias merely serve to fix the sand, and will properly give way to the larger acacias, to eucalypts, pines, casuarinas, and other timber trees. One large district which can be reclaimed in this way covers many square miles of coast in Monterey, San Luis Obispo, Santa Barbara, and other more southern counties. The same is true of large areas north of Monterey and about San Francisco, and of large inland areas where the sand is decomposed granite, adapted to *Acacia aneura* and *A. salicina*. Von Mueller recommends *Acacia excelsa* and the very shrubby form of *Acacia longifolia*, as valuable sand binders; both yield tanbark. According to the same authority, *Acacia giraffea* (Willd.), of South Africa, and *Acacia seyal*, of the Nubian Desert (neither of which has been tested in California), are especially drought resistant and have great economic value.

GOLDEN GATE PARK, SAN FRANCISCO.

The best evidence of the adaptation of nearly all of the Australian acacias to the sandy soil of the California seacoast, clear down to the ocean beach, directly exposed to heavy gales and dense salt fogs, is in Golden Gate Park, San Francisco, where they have been chiefly instrumental in making a magnificent park out of a waste area of drifting sand. The planting during the past 40 years furnishes the best record of the successful use of acacias in reclaiming sand dues that exists. At the present time there are superb thickets and copses of acacias, thoroughly established and naturalized, so that they require no cultivation. Not only that; they are extending themselves from year to year, within a stone's throw of the Pacific Ocean, and fixing the vagrant sands. Further inland similar thickets are changing to acacia forest, capable of yielding firewood and timber.

The planting began in 1870, and the stock used was chiefly for ornamental purposes. Trees from this first experiment are now standing in the older portions of the park—magnificent specimens of *A. melanoxylon* and *A. decurrens*. But even with this earliest plantation, some were set out on the sand hills to the west, simply as an experiment.

The westernmost 730 acres of this famous park consisted of great shifting dunes of sterile sea sand. The larger native growths were scattered evergreen scrub oaks and willows in the hollows between the barren sand hills. Often the dunes would drift over the willows and oaks and kill them. The struggle of these plants is clearly shown by the fact that lupin roots have been traced downward for more than 25 feet in the sands, while the roots of the willows have been followed for more than 100 feet from the main stems.

While many of the original acacias have been removed for one cause or another, this still remains a wonderful object lesson in acacia planting. Some trees have been taken out in the necessity for thinnings; others have had to give way to new driveways as they reclaimed the sands, thus making it possible to extend the cultivable portions of the park. The buildings for the Midwinter Fair of 1893 and the shelter tents for the homeless after the earthquake and fire of 1906 further diminished the thickets and groves, yet the arboretum contains the only California specimens known to the author of *Acacia discolor*, *A. capensis*, and *A. coccinea*.

These complete and long-continued tests indicate that the shrubby Australian acacias will cover sand dunes rapidly and efficiently and will furnish firewood in from 8 to 10 years from seed. While all this stock was nursery grown and transplanted, experiments in other places seem to indicate that seed can be sown directly on such sand slopes, and that the expensive nursery and transplanting practice,

while securing quicker results, is not really necessary. It should be kept in mind, too, that these plantations were not irrigated, and were left to shift for themselves.

At the very shores of the Pacific, south of the famous Cliff House, a place familiar to thousands of tourists, there are large low growths of acacia and albizzia, so close to the beach that the spray from the winter waves dashes over them. They are from 4 to 8 feet high, with close-matted roots and tops, which bind the sands and completely cover them. They are from 6 to 16 years old, and their stems are from 1 to 2 inches through. The albizzias begin to flower in November, and self-sown seedlings are numerous. They seem better able than the acacias to extend their foothold on the beach's extreme verge. The acacias bloom in February; they make few seeds in such an exposed situation, though farther inland they seed well.

A little farther east and more inland, at about a thousand feet from the ocean, are more acacias, principally *Acacia longifolia*, growing among and over the sand hills, and though these are no older than the beach thickets they are from 8 to 12 feet high, because they are more sheltered and in less saline soil and atmosphere. A very large area which was hopelessly barren has been rendered attractive by the acacia copses. There are a few sand willows and pines, but the bulk of the growth is of planted and self-sown acacias.

Still farther east, nearly half a mile from the ocean, but still on land which was formerly sand dunes, the acacias are somewhat older and give each other good protection. These are from 20 to 30 feet high, with stems from 10 to 18 inches in diameter. Like all the others in the sand hills, these trees never received any artificial application of water. They were set out during the rainy season from seed boxes when only a few months old, and were then left to fight their own battles. In many cases the little trees grew from 3 to 5 feet during the first spring.

In November some of the acacias on the sunny sides of the dunes show bloom, and by the middle of January the whole expanse is golden with blossoms. This is two weeks ahead of the same species on the beach.

The mixed plantations along railroad cuts in and near Golden Gate Park and in some of the older groves where good soil has been spread over the sand are now large and thrifty, fairly deserving the name forests. Individual specimens are 24 inches in diameter and are fit for timber.

There has always been a struggle between the sand and the vegetation, though in the end the acacias seem to be able to fix the soil, even though they have been temporarily killed back. Where the

sand has drifted in over the tops the trees have sprouted again from below, and have formed impassable thickets. These close clumps on pure sand do not seem able to grow higher than from 20 to 25 feet, but even this far surpasses the native scrub oak and willow. As the park reclamation is made complete, however, and richer soil spread out on the sand, *Acacia decurrens* and other large species immediately begin to grow sturdily, and age for age are as handsome and thrifty as those anywhere else in California.

The especial value of these experiments upon California sand dunes is the proof it gives that useful and ornamental plantations can be made in such places. The natural desirability of residences on or near the seashore is greatly increased if such homes can be sheltered by groves and thickets. Acacias not only furnish these groves, but help to retain the soil, furnish firewood, and, in the end, timber and tanbark. Nearly all of the acacias are beautiful in leaf and flower and graceful in their growth. Along the California coast, therefore, as on that of the Mediterranean, they should be extensively planted.

Correlating the Golden Gate Park and the South African experiments, species which seem most desirable for American plantations, for rapid reclamation and maximum profit are *A. pycnantha*, *decurrens*, *leiophylla*, and *longifolia* sown in combination with shrubby species which will give way when the sands are fixed and forest conditions established. The shrubby form of *A. longifolia* is the variety *sophoræ*, the spreading coast wattle; the tall form which might follow this is the Sydney golden wattle, the bark of which yields from 15 to 20 per cent of tannin, used chiefly for sheepskins. When the sand-dune area has become well covered with *A. pycnantha* and *A. decurrens* it is a tanbark proposition. If the object is mainly shelter and beauty, with the production of some tanbark as a secondary consideration, the final species would well be *A. cyanophylla* (blue wattle), *A. decurrens* var. *mollis* and *A. baileyana*, as well as *A. pycnantha*. All these thrive near the seashore and on light soils. *Acacia longifolia*, *cyanophylla*, and *pycnantha* are the best ones for inland localities up to an elevation of from 2,000 to 2,500 feet in southern California, though the amount of frost rather than the elevation furnishes the deciding factor. In this list, all except *A. baileyana* yield tanbark. A purely ornamental plantation on the seacoast might include several hundred species, and would be exceedingly attractive.

Because of its rapid growth in California and its value as a shelter and a sand binder *Albizzia lophantha* should be extensively planted. It is one of the best species for obtaining a quick sand cover, and reproduces itself faster than any of the true acacias. It is particularly advantageous as the extreme advance guard of acacia plantations nearest to the shore.

ACACIAS FOR TANBARK.

At the present time the chief commercial value of acacias seems to be for tanbark, although even with the tanbark species there are important by-products. The tanbark industry is bound to increase in importance; tanners are searching farther and farther for the materials they need, especially since, for the treatment of heavy, high-grade leathers, no real substitutes for the best vegetable tans have yet been discovered.

Important Tanbark Species.

All of the leading tanbark acacias are from Australia and are generally known as wattles. This term is of local origin. Early settlers in the Australian bush made huts by weaving or wattling green branches together, and since acacias were most often used the name wattle has since been applied to the strong-growing species. In his time Von Mueller designated only five acacias as wattles, though he names many others as yielding tanbark. Dr. Maiden applies the term to more than 30 species whose bark he has tested. It is evident, however, that while many will yield bark worth using, when the tree is cut for timber (this is true of all the more valuable timber species) only *A. pycnantha* and the best varieties of *A. decurrens* justify planting for tanbark alone. *Acacia decurrens mollis* and *decurrens normalis* are the largest and best of the *decurrens* forms, and are stronger growing trees than *A. pycnantha*, but the latter yields the richer bark. These trees, then, are all that are worth serious attention for tannic acid. *Acacia melanoxylon, decurrens, dealbata, longifolia,* and others whose timber is of first importance yield tanbark only as a by-product.

The two *decurrens* varieties (*Acacia decurrens mollis* and *A. decurrens normalis*) may be taken as the typical tanbark acacias. Von Mueller's statement in 1882 of the value of their bark can scarcely be improved upon:

> It varies in its content of tannin from 30 to 40 per cent in bark artificially dried. One and one-half pounds of the bark give 1 pound of the leather, while 5 pounds of English oak bark are requisite for the same result. Melbourne tanners consider a ton of black wattle bark sufficient to tan 25 or 30 hides; it is best adapted for sole leather and so-called "heavy" goods.

Acacia Pycnantha.

Acacia pycnantha is now strongly recommended by all who have studied tanbark production from this genus. The Kew Bulletin of 1893 especially urges the planting of *A. pycnantha*. Naudin says that the bark of this species has been known to contain 46 per cent of tannic acid, and that ordinarily it yields from 35 to 40 per cent. According to Von Mueller it is "second perhaps only to *Acacia*

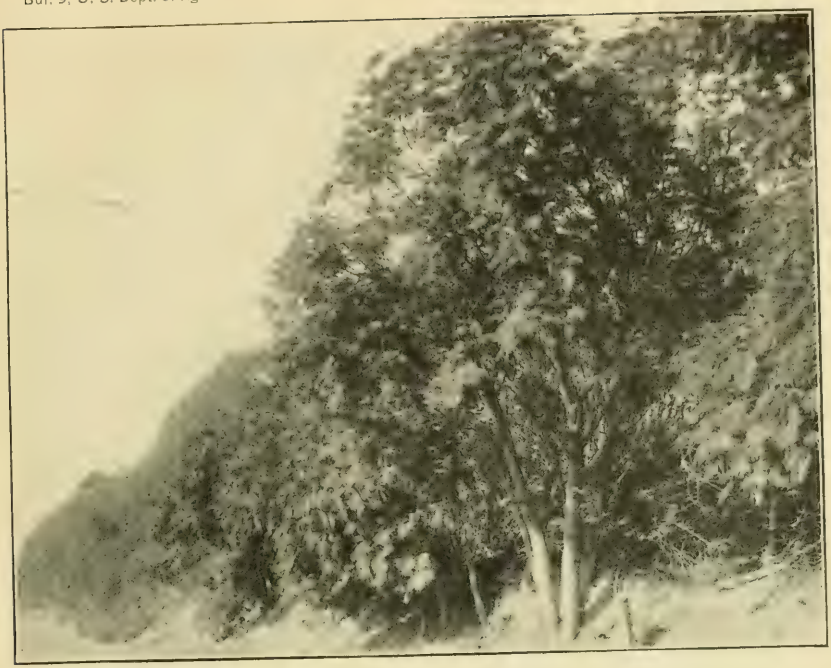


FIG. 1.—DRIFTING SANDS HELD IN PLACE ALONG A CAR TRACK BY A PLANTATION OF ALBIZZIA LOPHANTHA, NEAR THE CLIFF HOUSE, SAN FRANCISCO.

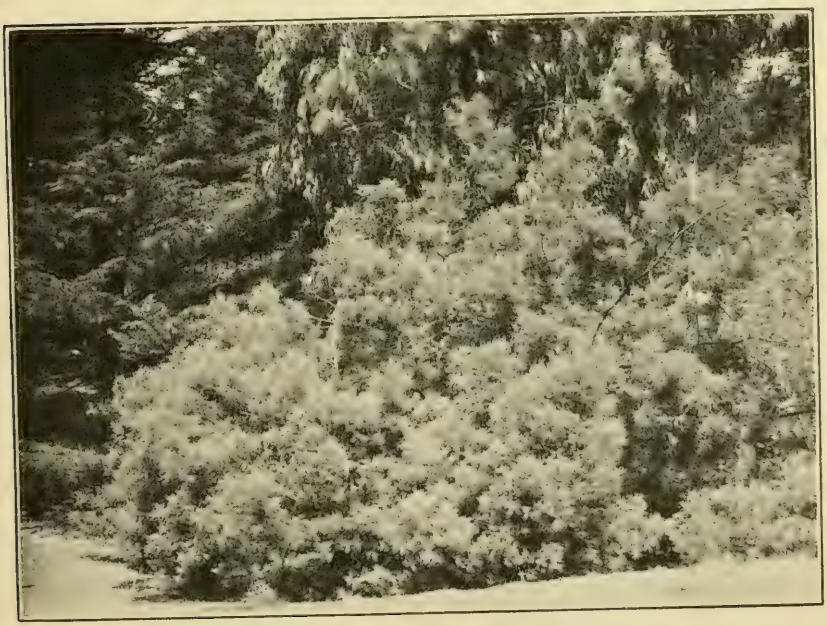


FIG. 2.—A MASSED PLANTING OF ACACIA LONGIFOLIA IN THE RECLAIMED PORTION OF GOLDEN GATE PARK, SAN FRANCISCO. BLUE GUM, EUCALYPTUS GLOBULUS, AND MONTEREY CYPRESS IN THE BACKGROUND.

FIG. 1.—ACACIA LONGIFOLIA FROM SELF-SOWN SEED, BERKELEY, CAL.

FIG. 2.—YOUNG GROWTH STARTING FROM A BROKEN AND SCARRED TRUNK OF ACACIA DECURRENS MOLLIS, BERKELEY, CAL.

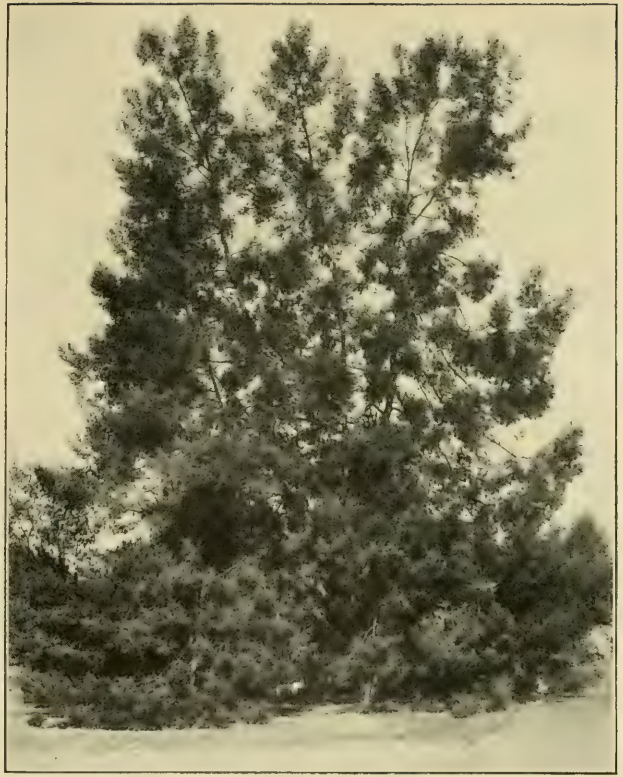


FIG. 1.—A FIVE-YEAR-OLD ACACIA DECURRENS NORMALIS FROM SEED, POMONA, CAL.

FIG. 2.—A SPECIMEN OF ACACIA DECURRENS NORMALIS, 20 YEARS FROM SEED, SANTA MONICA, CAL.

FIG. 1.—TANBARK ACACIAS OF SANTA MONICA, 20 YEARS OLD AND FROM 30 TO 40 FEET HIGH. ACACIA DECURRENS MOLLIS AND DECURRENS DEALBATA.

FIG. 2.—TANBARK ACACIAS (DECURRENS MOLLIS) AT BERKELEY, CAL.

decurrens in importance for its yield of tanner's bark; the quality of the latter (*A. pycnantha*) is sometimes even superior to that of the black wattle, but the yield is less." Dr. Maiden says it is "one of the richest tanning barks in the world; a richer may exist, but I do not know of it." The sample bark that he analyzed in 1880, by Lowenthal's improved process, showed tannic acid 46.47 per cent, extract 74.07 per cent. This was, of course, an extremely rich sample. Thirteen samples from the Government farm at Bellair, South Australia, taken from trees at various ages and grown on different soils, ranged from 28.5 to 38.5 per cent tannic acid and from 57.75 to 68.35 per cent extract. The trees were from 3 to 7 years old; the soils were light and shallow and mostly on a bedrock of hard sandstone.

This is the true golden wattle of Von Mueller, and when in bloom it is strikingly attractive. It is considerably smaller than any of the *A. decurrens* forms; hence it may not yield as much bark per acre as *Acacia decurrens mollis*. But the trees can be set closer together, and the quality of the product is unsurpassed.

ACACIA DECURRENS DEALBATA.

Good barks of *Acacia decurrens dealbata*, or silver wattle, contain about 25 per cent of tannic acid. In some situations it grows faster than the normal *A. decurrens*, and when full grown always forms a stately tree. It requires rich moist soil and a frostless locality. On river banks in Australia it reaches a height of 150 feet; in California the largest recorded specimen is 90 feet high and 2½ feet in diameter. Several considerations militate somewhat against its planting. In the first place, it will hardly pay to plant it where the more productive *A. pycnantha* and *A. decurrens* will thrive; and it is not frosthardy. The root system of *A. dealbata*, like that of *A. melanoxylon*, is mainly at the surface, and the trees are easily blown over.

ACACIA MELANOXYLON.

The appearance of *Acacia melanoxylon*, the black wood of southeastern Australia, is very different from that of the feather-leafed acacias. It belongs, with *Acacia longifolia*, *A. pycnantha*, and most of the Australian species, to the wonderful phyllodinous acacias. With these the true leaves are suppressed, or nearly so, and the flattened leaf-stalks (phyllodia) perform the functions of leaves. The first foliage from seedlings of any of these species are delicate, feathery, bipinnate leaves; but the leaf-stalk soon broadens, lengthens, and hardens, finally changing to a leathery phyllodium. Sometimes a few of the true leaves will persist for a long time at the

terminals of the former leaf-stalks, and occasionally they may show on the younger growth.

The tree is less valuable for tannin than for timber; but a tree so large and rapid-growing, the bark of which has a 15 or 20 per cent tannin content, should not be neglected in calculations for tannin production, especially since the development of the manufacture of tannin acid extract. *A. melanoxylon* properly belongs to moist and not frosty situations, and its roots are surface feeders. When young it is particularly susceptible to drought, and will die on soil the least bit arid; moreover, it succumbs readily to desiccating winds, such as the drying northers of California. Von Mueller reports it as being hardy (with some forms of *A. decurrens*) on the Isle of Arran, Scotland. This does not, however, prove the hardiness of the tree so much as it does the variation of local climatic conditions, since *A. melanoxylon* has been injured by frost (7° F.) at Chico, Cal. It is useless to plant it in arid uplands, but its resistance to trying city conditions and its power of utilizing sewage make it of value as a street tree.

Tanbark Acacias Abroad.

AUSTRALIA AND NEW ZEALAND.

In Australia acacias have been utilized for tanbark for a long time, the natural supplies being drawn upon exhaustively and the artificial culture of acacias consequently neglected, since there was an abundance of tan-yielding species on hand.

Some 35 years ago, however, Baron von Mueller called attention to the rapid depletion of the natural supply, and from that time a voluminous and important official literature upon acacias and acacia culture grew up. Since 1875 these reports have aroused general as well as local interest in the planting of the species for tanbark.

The three earliest and most careful estimates of planting costs, based upon actual experiments in 1878, 1884, and 1889, give, respectively, the following figures:

(1) *Acacia decurrens*, 100-acre basis, rented at $1.50 an acre a year, 400 trees planted per acre:

Aggregate sales of bark, first 8 years, 1,215 tons	$23,290
Aggregate expenses, including interest	7,270
Profit	16,020

(2) *Acacia pycnantha*, 100-acre basis, bought at $15 per acre; 1,200 trees to the acre:

Aggregate sales of bark, first 7 years, 500 tons	$12,000
Aggregate expenditure, first 7 years, including interest	8,700
Profit	3,300

(3) *Acacia pycnantha*, 100-acre basis, sowed broadcast and thinned to 1,200 trees to the acre; land rented at 8 cents an acre a year, under the provisions of the wattle-culture act passed in Victoria Colony in 1889:

Aggregate sales of bark, first 7 years, 642 tons	$23,120
Aggregate expenditure, first 7 years, including interest	7,360
Profit	15,760

While these estimates differ considerably, based as they are upon various crop prices, land values, production costs, and yields, they are still suggestive. In fact, the only point in common between the three plantations was that in each case there was good preparation of the soil and careful cultivation.

The Queensland Agricultural Journal recently reported that in Auckland, New Zealand, an otherwise useless tract of land of about 4,500 acres planted to *Acacia decurrens* gave the following results:

Aggregate sales of bark, per acre, first 8 years	$142
Aggregate expenses, per acre, first 8 years	70
Profit (not including 5 cents per acre per year, and not including interest)	72

In South Australia, on the unproductive "fern hills" of white sand and on dry limestone ridges, acacias grow well. Such land can be rented at less than 4 cents per acre a year, and ought to yield from $70 to $80 per acre at the end of 8 or 9 years. Better soils will give proportionately better yields, but the striking thing about the New Zealand and Australian reports is the unanimity of opinion as to the value of wattles upon poor soils.

SOUTH AFRICA.

Thirty years' experience with tanbark wattles in Cape Colony, Natal, and other places in South Africa has been quite as interesting as the experience with sand-binding acacias.

Originally introducing *Acacia saligna* for tanbark, Cape Colony made strenuous efforts to plant large areas. In some districts material was needed for huts, fences, and fuel, and this made a demand for small stuff which would grow rapidly. This demand led to the planting, in some instances, of as many as 20,000 acacias to the acre, the plantations being thinned out at the end of the fourth year and the wood and bark of the trees removed in thinning being sold. In some plantations trees were set in rows 4 feet apart or alternated with cluster pines. By 1890 about 150 tons of bark were marketed, and in 1891 nearly 2,500 tons, partly from government forests and partly from trees belonging to settlers.

As soon as the superiority of other tanbark species was recognized, *Acacia saligna* was dropped and better species planted on an exten-

sive scale. In 1896, for example, 494,873 *Acacia decurrens* were set out in one of the Crown forests. At another place 10½ acres were sown broadcast with this species, and on one-half acre seed was drilled in.

Tanbark acacias have been planted more or less extensively, especially since the war in the Transvaal. The assistant conservator of the Transvaal forests published a full report on acacia culture in the Transvaal Agricultural Journal for January, 1910. In this he states that after extensive trials *Acacia decurrens* (varieties *normalis* and *mollis* or *mollissima* and *Acacia cyenantha*) are found to be the best sort, with the *decurrens* type in the lead. Photographic illustrations in the report show dense, mature wattle plantations and also the processes of stripping and preparing the products for market. He states that wattles can be grown anywhere in the Transvaal, but most successfully at elevations of from 3,000 to 5,000 feet on the high plateaus, with a preference for eastern slopes. The most suitable soil is a light red or chocolate well-drained loam. The annual rainfall is from 30 to 40 inches and there are no extreme frosts. Acacia culture is spoken of as a most promising industry.

NATAL.

Probably the most suggestive and interesting chapter in the history of commercial planting of acacias is furnished by the rise of the wattle industry in Natal during the past 30 years. The yield from cultivated trees surpasses that which has been obtained from natural growth, the two leading forms of *Acacia decurrens* being the most valuable kinds, with *mollis* as the hardier variety. In 1886 the acacia tanbark export was valued at $55. By 1902 the exports had risen to $370,000 worth, and this does not include any report of material used for local consumption. Several companies planted 3,000 acres and some are adding at the rate of a thousand acres a year. It is claimed for the industry that it yields a high rate of interest without high-priced management and utilizes soils unsuited to general cultivation. In 1906 Natal had more than 30,000 acres in acacia plantations and at the present time this area is more than doubled. Mr. David G. Fairchild, in charge of Foreign Seed and Plant Introduction, United States Department of Agriculture, states that the black wattle most generally planted has been *Acacia decurrens mollissima*.[1] He notes that a few years ago wattle bark reached the price of $82.79 a ton and this high price greatly stimulated planting. What is known as the Townhill plantation, 2,400 acres, situated 2,700 feet above sea level, was begun in 1892. The topography was rolling hills and the soil a light red loam with sand, gravel, and clay. The tract was

[1] Miscellaneous Papers, Bulletin 51, Bureau of Plant Industry, U. S. Department of Agriculture.

grass covered and therefore required no clearing. Rows were marked at 12 feet apart and the seed was hilled 6 feet apart in the rows. Corn was grown between the rows for the first two years in order that its yield would help to reduce expenses. At 10 years old the trees were 10 inches in diameter.

All the work on this 2,400 acres is done by 60 natives, who peel, cut, and dry the bark, stripping it at any season that it will peel easily. They use drying sheds of galvanized iron, each one of which holds about 6 tons of bark.

The gross receipts from 10-year-old trees at the price of $32 per ton, when Mr. Fairchild made the study, was from $161 to $193 an acre. The operating cost for harvesting the product was $7.30 a ton or $43 an acre. The 10 years' care of the land, the cost of the land—in this case only from $5 to $6 an acre—and interest were said to be covered by the sale of the wood for mine props, fuel, and small timber. No replanting has been necessary, since thousands of seedlings come up and cover the ground.

Another valuable publication on acacias in Natal has been furnished by Mr. T. R. Sims;[1] but the most complete publication which covers the entire industry in 10 countries is the third edition of Dr. Maiden's "Wattles and Wattle Barks."

NORTH AFRICA.

Johannes Paessler, of Levertechn, published in 1910 a paper on acacia bark grown in North Africa, in which he speaks of *Acacia decurrens*, *decurrens mollis*, *decurrens dealbata*, *pycnantha*, and *penninervis*. According to his report only the best species are planted and the tannin yield, which was less than 30 per cent, is now increasing. *Acacia decurrens* in German East Africa, at an elevation of from 4,000 to 4,500 feet is ready for gathering at five years, and yields a bark of higher tannin content than that from Natal. At Freiburg Station 260 bark samples were analyzed by the filter method since 1901, with the following averages:

	Per cent.
Tannins	33
Nontannins	8.5
Insolubles	43
Water	14.5

There is a smaller proportion of nontannins to tannins in acacias than in the domestic barks, such as oaks. The sugar content is very low, which gives the acacias only slight acid-forming power. Ground acacia bark, according to this report, in Germany in 1910 cost $55 a ton, which makes the tan worth about 8½ cents a pound.

[1] "Tree Planting in Natal," Chapter 9: "The Black Wattle Industry," Bulletin 7 of the Natal Department of Agriculture, Pietermaritzburg, 1905.

HAWAII.

Prof. Jared C. Smith has made a full and careful report of experiments with black wattles in Hawaii.[1] In this he states that acacias have been grown in the Hawaiian Islands for about 40 years, thriving on heavy soils with a rainfall of from 80 to 150 inches. The remarkable fact in connection with this exceedingly heavy rainfall is the adaptability of the acacias to various conditions from drought to deluge, and points to their possible use in such locations as the Colorado River bottoms and along the Gulf coast.

Six acres of 13-year-old trees yielded $254.84 per acre. The bark brought about $139 (5.9 tons at $23.31 per ton). The wood sold for fuel yielded about $114.

According to Mr. Smith, one man with good tools and a team can take care of 250 acres of black wattles with ease when it has once been sown and thinned. "One pound of good seed should plant 10 acres." This illustrates scientific progress, since many planters have been in the habit of sowing 5 or 10 pounds to the acre. Yet *Acacia pycnantha* has about 23,800 seeds to the pound; *A. normalis*, about 28,500, and *mollis* 38,500. The present Australian practice is to sow from one-third of a pound to a pound of seed an acre, but since 1,200 trees is an abundant stand and 800 is better, a pound of good seed should sow 10 or more acres. In the famous Tantalus acacia plantation in Hawaii, the trees of 13 years vary from 6 to 18 inches. A 10-year-old tree would yield 100 pounds of green bark, which is equal to 50 pounds dry. The best trees yield as much as 200 pounds.

TANBARK ACACIAS IN CALIFORNIA.

While there are no commercial plantations of tanbark acacias in the United States, the leading tanbark acacias have long been grown at the California Experiment Station at Berkeley and at various substations. Their product has been analyzed and compared with that from the California oaks and from canaigre (*Rumex hymenosephalus*). In the bulletins of the California Experiment Station and of the Federal Forest Service[2] attention has been called to the rapid disappearance of California tanbark oak (*Quercus densiflora*), the tannin from which has given high reputation to California-tanned heavy leathers. The constantly increasing cost of the bark has been noted and at the same time the deterioration of its quality, since mere bushes and saplings are now being stripped for the thin young bark, incomparably inferior to the old thick bark from the boles of mature trees. The necessity of securing a supplement to or substitute for

[1] Bulletin 11, Hawaiian Experiment Station, 1906, "The Black Wattle in Hawaii."

[2] Bulletin 75, Forest Service, U. S. Department of Agriculture, California Tanbark Oak, by Willis Linn Jepson, issued Sept. 20, 1911.

this source of tanning material has been recognized for some time; the planting of wattles would seem to offer a solution for the difficulty.

POSSIBILITIES OF GROWTH.

There are enough trees in California to furnish seed; and the growth of individual trees has already demonstrated the fact that tanbark acacias should be successful over large areas. On the Pacific coast and in the Southwest there are many districts well adapted to tan-yielding acacias; and there should be a market not only for the bark but for fuel wood after the bark is removed. Even where isolated trees suffer from frost, groves of trees sheltering each other will not be subject to the same damage. *Acacia pycnantha*, even when small, has withstood the winters of Cholame Valley, Monterey County, in a district where peach, cherry, and grape crops have been lost through late frosts.

While the amount of rainfall which acacias require seems not to have been determined, it is generally assumed that 16 inches a year is the minimum for *Acacia decurrens*. Yet deep-rooted saplings will thrive on much less. The reports of the University of California show that in the drought years of 1897, 1898, and 1899 acacias of the leading tanbark species grew well with rainfall of from 4.8 to 8 inches. In Los Angeles County young trees set out in the spring of 1897, and thus subjected to three successive drought seasons, made growths of from 4 to 6 feet in height a year, and in 1911 were 2 feet in diameter. These and other instances justify the belief that some of the best Australian acacias will thrive in America under almost desert conditions. If they can be made to supplant large areas of chaparral they will maintain a protective covering for the soil and produce in addition a profitable crop.

The increasing demand for tanbark ought to direct attention to these drought-enduring wattles. In California the native oak has advanced in price from $6 per ton in 1870 to $48 at the present time. Bark cutters are now forced to seek the most remote and rugged canyons in Mendocino, Humboldt, and Del Norte Counties, and sometimes carry out the bark on pack mules. In the Mendocino forests, once thought to furnish a practically inexhaustible resource, the writer has seen the bark cutters stripping trees only 3 inches in diameter.

California has a large investment in the tanning industry, and California leathers are shipped to all parts of the world, so that the disappearance of the main source of tannin supply becomes a serious problem.

It should be possible to produce wattle bark for market on low-priced land from cheap home-grown seed. While it is useless to

expect to rent land in America at the Australian price of 4 cents ar acre a year, there is nevertheless cheap and suitable land in Cali fornia and the Southwest.

TANNIN CONTENT OF CALIFORNIA BARKS.

The first acacia barks analyzed by the University of California were those of *Acacia decurrens mollis*, *A. decurrens dealbata*, and *A pycnantha*. In the report upon these barks [1] it was shown that the California-grown bark of *mollis* was twice as thick as that of *dealbata* of the same age and that it yielded about twice as high a percentage of tannin. This agrees very nearly with comparisons made upon barks grown in Australia and in Algeria. The actual tannin contents of these three barks grown at Berkeley were as follows:

	Per cent.
Acacia decurrens mollis	48.6
Acacia decurrens dealbata	24.8
Acacia pycnantha	46.8

Dr. Hilgard states that these tannin determinations were made by the permanganate method, repeatedly checked by the gelatin or hide-strapped method, with but trifling differences in the results, so that the figures fairly represent what hides will take up.

One of the trees, 13 years old when cut for these experiments, was 12 inches in diameter at 3 feet above the ground, and 40 feet high.

It will be observed of these analyses that California-grown *A. pycnantha* bark, contrary to Australian experience, did not exceed *mollis* in richness of tannin content. Later analyses seem to confirm this general fact: That *A. decurrens normalis* and *mollis* are proportionately richer in tannin when grown in California than when grown in Australia. As yet, however, the quantity of bark which has been produced is not sufficient to settle this interesting and important point, though everything points to the desirability of both of these forms of *Acacia decurrens* for planting in California, particularly in the Coast Range, where the bark so far tested has been grown.

Another report [2] gives some interesting statistics about the plantation at Santa Monica, which has been under charge of the University of California since 1894. This report states that *Acacia decurrens* and *A. pycnantha*, 25 months from seed (20 months planted in the field), have grown twice as rapidly as the same species mentioned in Australian reports. Many trees of this age had attained a height of 16 feet and the very poorest were 2 inches in diameter and 9 feet high. Mr. Lyon estimated that at 4 years of age such a plantation would yield a crop of bark equal to that of 7 or 8 year old Australian groves; that is, from 80 to 90 pounds of bark to a tree.

[1] Report of Dr. Hilgard, Jan. 23, 1884.

[2] Third Annual Report of the First Board of Forestry of California; Chapter on Acacias, by W. G. Lyon, State Forester, 1890.

Fig. 1.—Twenty-Year-Old Acacia melanoxylon, 40 Feet High and 16 Inches in Diameter, Grown on Poor, Gravelly Soil at Santa Monica, Cal.

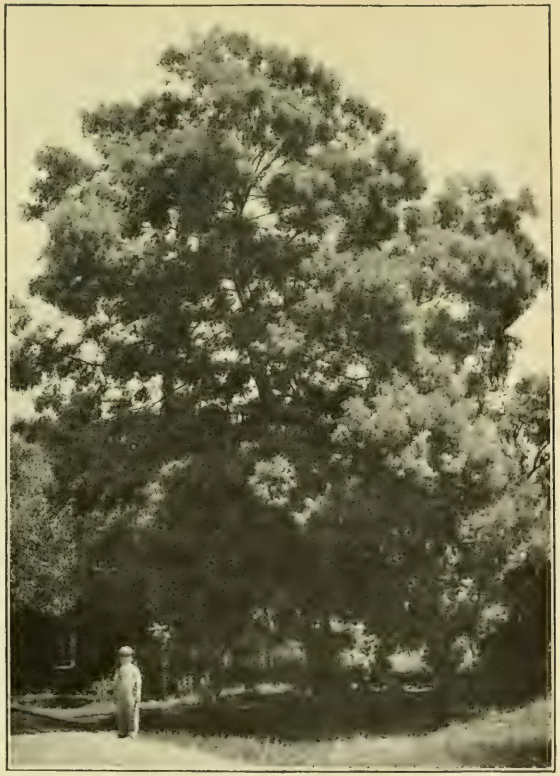


Fig. 2.—Twenty-Year-Old Acacia decurrens dealbata, Near Niles, Cal.

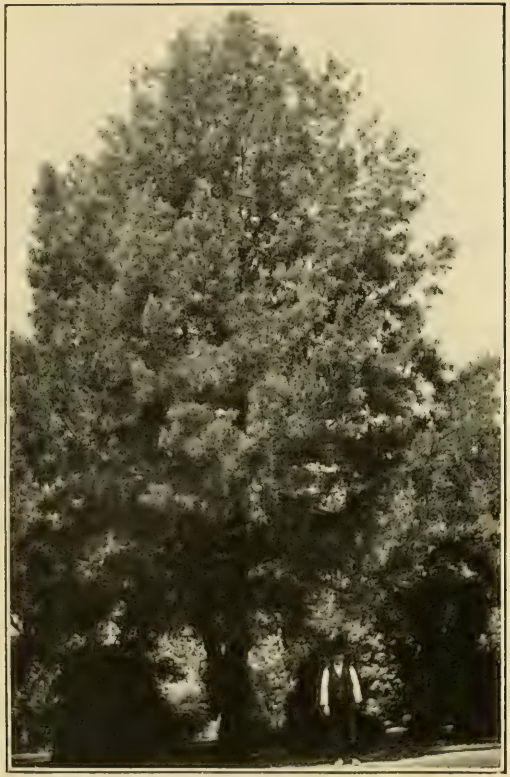


FIG. 1.—TWENTY-YEAR-OLD ACACIA MELANOXYLON ON A FARM NEAR NILES, CAL.

FIG. 2.—ACACIA DECURRENS NORMALIS ON A FARM NEAR NILES, CAL.

There are reports of trees of *Acacia decurrens mollis* in southern California which when 4 years old were 30 feet high and 8 inches in diameter.

A complete analysis of the tanbarks grown at Santa Monica Forest Station, made in June, 1898, by Mr. George Colby, of the California Experiment Station, gives the following results:

	Water in air-dried bark.	Tannin in air-dried bark.	Water-free substance.
Acacia decurrens normalis:	*Per cent.*	*Per cent.*	*Per cent.*
Bark, main tree	6.53	42.48	45.83
Bark, branches	8.28	36.57	39.98
Bark, large roots	5.28	31.35	33.10
Acacia decurrens mollis:			
Bark, main tree	7.60	45.98	49.76
Bark, branches	8.08	42.98	46.66
Bark, large roots	7.89	32.37	35.18
Acacia pycnantha:			
Bark, main tree	9.32	41.80	46.09
Bark, branches	8.67	38.66	42.34
Bark, large roots	7.10	47.02	50.58

Two points are brought out by these analyses: *Acacia pycnantha* alone showed a higher proportion of tannin than a bark with a large root, although this fact is likely to be true of the various forms of *Acacia decurrens*. The superior value of *Acacia decurrens mollis* is plain. All of these barks gave good results in practical tests by tanners. It should be stated that these results were not obtained from commercial plantations, and that notwithstanding the figures which were presented so many years ago by the University of California, no commercial plantations were set out. The principal reason for this was that at that time the demand for tanbark in California was sufficiently supplied by tanbark oak, which was then abundant; moreover, public attention had not been then directed to the possibilities of forest planting for timber, tanbark, and other products.

ACACIAS FOR TIMBER.

Throughout the world there is evidently an increasing demand for hardwoods. In the eastern United States, which probably furnished the best supply of hardwood lumber that has ever been known, the diminution of the supply has already caused readjustments in several industries which have depended upon it.[1] The foresters of South Africa, Algeria, and Australia are planting tons of acorns to grow future hardwood forests. California in particular, rich in conifers, has no hardwoods of commercial importance, and the introduced eucalypts present many difficulties in utilization.

Principal Timber Species.

Many of the acacias furnish useful and valuable timber and are not only beautiful in grain but durable in contact with the ground. Even

[1] Circular 116, Forest Service, U. S. Department of Agriculture, the Waning Hardwood Supply.

the smaller species have high value for tool handles, for furniture, and for various other useful and ornamental objects. Some of the best species yield very hard, heavy, close-grained, tough timber that is fairly comparable to walnut and rosewood.

Acacia melanoxylon.—Wherever it thrives *Acacia melanoxylon* is considered the most valuable of the timber acacias. The tree grows very rapidly and reaches a height of from 80 to 90 feet and a diameter of 3 feet. Von Mueller reports its strength as surpassing that of kauri and approaching the best American white oak. In his experiments a weight of 2,296 pounds is required to break a piece of *Acacia melanoxylon* 2 feet long and 2 inches square, supported at the ends. The Victorian Timber Board, in 1884, found that 956 pounds were required to break test pieces 1½ inches and 6 feet between bearings. This wood averaged 53 pounds per cubic foot, but its more usual weight is from 41 to 48 pounds. The tensile strength of good samples is reported by Mr. Campbell at an average of 27,500 pounds per square inch.[1] The Kew Bulletin for May, 1899, states that the timber of *Acacia melanoxylon* is sound and easily worked; that its prevailing color is brownish, striped with red and light golden, which made an "exceedingly beautiful" combination in the best specimens. The report adds that such a wood may be used to advantage in place of the best Honduran mahogany, and that some lots, while less ornamental, "are excellent for high-class turnery." Maiden says:

> Hard and close-grained; much valued for furniture, picture frames, cabinetwork, fencing, bridges, railway and other carriages, boat building, tool handles, gunstocks, naves of wheels, crutches, parts of organs, pianofortes, billiard tables, etc.; almost equal to American walnut; excellent wood for handling under steam; largely used for oil casks.

It is also used for oars, buggy shafts, bookcases, tables, and cabinetwork of various kinds.

Growth notes on *Acacia melanoxylon* in California show clearly its importance as a timber species. About a hundred tree measurements in different portions of the State, from Shasta south to San Diego, taken at various times between January, 1910, and June 1, 1913, show that on average soils, with an annual rainfall of from 15 to 30 inches, and without irrigation, trees 20 years old average 40 feet in height, with a stem diameter of 18 inches.

Some of the single measurements of older trees are as follows:

At Hotel Del Monte, Monterey, a tree 30 years old measured in May, 1913: Height, 70 feet; diameter at 4 feet from the ground, 2 feet 8.4 inches. At Golden Gate Park, San Francisco, a tree 35 years old, in almost pure sand, measured winter of 1912–13: Height, 60 feet; diameter, 4 feet from the ground, 2 feet. Another, 36 years old, on better soil: Height, 75 feet; diameter, 4 feet from

[1] Proceedings of the Royal Society of Victoria, 1879.

ground, 2 feet 8 inches. At Niles, a tree 46 years old, on side valley soil, 76 feet above San Francisco Bay, top broken off at height of 65 feet, though the tree had been about 80 feet high, diameter 2 feet 6 inches. Near Alvarado, a tree 45 years old, on rich soil, 85 feet high, diameter, breast high, 3 feet 9 inches.

All portions of the Sacramento and San Joaquin Valleys appear well adapted to the growth of *Acacia melanoxylon*. At the Chico forestry station and elsewhere it showed no injury, except to the young tips of the top branches, during the low temperature of the coldest seasons between 1890 and 1913 (16°, 14°, and 12°). Large eucalypts were killed to the ground by these frosts.

The bark of this species yields about 11 per cent of tannic acid, which could be utilized profitably when the timber is cut by concentrating it in the form of an extract. The inner bark, as with some other acacias, yields a valuable bast or fiber material.

Acacia decurrens group.—There is little difference in the woods of the three leading varieties of the *Acacia decurrens* group (*normalis*, *mollis*, and *dealbata*), but the last two grow more rapidly and attain the larger size. *Dealbata* trees have been measured and found to be 100 feet high and 4 feet in stem diameter. This variety has been naturalized in southern India since 1840 and extended over a large area. The timber of all three varieties is moderately hard, light brown in color, easily worked, and strong; it is used by coopers and house builders; it is valuable for posts, for rustic work, for mine props under ground, and for fuel. Its weight is about 47 pounds to the cubic foot.

Acacia decurrens normalis and *mollis* are more generally planted than *dealbata*. Von Mueller gives the weight of their timber at from 45 to 48 pounds per cubic foot. Maiden reports that three slabs of *normalis* at the Technological Museum, seasoned for more than 25 years, weighed, respectively, 52, 53, and nearly 63 pounds per cubic foot.

Other timber species.—Many other species of acacia yield valuable timber. Of those listed, all have been grown in California.

Acacia acuminata.—Stem diameter, 12 inches. Wood strong and very hard, red-brown in color, and durable. Has a raspberry-like scent.

Acacia aneura.—Stem diameter, 10 to 12 inches. Exceedingly hard and strong wood of a dark-brown color.

Acacia arabica.—Stem diameter of 2 feet. Wood used for boats, water wheels, and many implements, on account of its strength and durability. The tanbark is a by-product of this species. (See pl. II.)

Acacia armata.—Shrub or small tree. Wood beautifully grained and durable.

Acacia aulacocarpa.—Wood heavy, hard, tough, light red. A cabinet wood.

Acacia bidwilli.—Stem diameter, 18 inches. Timber hard. Takes a good polish.

Acacia binervata.—Stem diameter, 12 inches. Wood close-grained, tough, light, called "hickory." Used for ax helves.

Acacia cunninghami.—Stem diameter, 12 inches. A dark-colored and heavy cabinet wood.

Acacia doratoxylon.—Stem diameter, 12 inches. Wood hard, tough, heavy, durable; very useful timber for buggies, whiffletrees, wagon poles, and furniture.

Acacia falcata.—Stem diameter to 12 inches. Spoken of as another hickory. Wood heavy, hard, and tough; yellow and light brown; easily bent into sharp curves by carriage makers. Used also for stock-whip handles.

Acacia farnesiana.—Stem diameter in some regions 6 inches. More valuable for its perfume-yielding flowers. A native of both hemispheres. Wood close, heavy; much used in India for ship knees and tent pegs.

Acacia glaucescens.—Stem diameter 18 inches. Wood dark, resembling rosewood, fragrant and close-grained; used by cabinet-makers and for tool handles.

Acacia harpophylla.—Stem diameter 18 to 24 inches. Wood brown, hard, heavy, elastic, straight-grained; has the fragrance of violets; much used for turnery; lasts many years in the ground.

Acacia homalophylla.—Stem diameter 1 foot. Wood hard, durable, and heavy (specific gravity 1.124), very fragrant; used for fancy articles, cabinet work, and tobacco pipes.

Acacia implexa.—Stem diameter 12 inches. The wood resembles that of *Acacia melanoxylon*, and is used for cogwheels and wagon hubs.

Acacia longifolia and its varieties have stem diameters of 9 to 12 inches. The wood is white, yellow, and brown in color, light, tough, hard; used for handles of axes and other tools. *A. longifolia* and its varieties are the most valuable among the sand-binding species.

Acacia macradenia.—Stem diameter 12 inches. Wood strong, hard, and blackish. Takes a fine polish.

Acacia neriifolia.—Stem diameter 12 inches. Wood light yellow and dark brown; handsome, close-grained, durable; used in cabinet work.

Acacia pendula.—Stem diameter 12 inches. Wood very hard, close-grained, richly marked, dark in color, very fragrant; used for veneers and fancy cabinet work.

Acacia pycnantha.—Stem diameter 9 inches. Wood very tough, weighs about 51 pounds to the cubic foot; used for staves, bobbins, and various articles of turnery.

Acacia salicina.—Stem diameter 15 inches; wood heavy, handsome, dark brown in color; weight of cubic foot 47 pounds; takes a high polish; much used for furniture.

Acacia stenophylla.—Stem diameter 20 inches. Wood very solid, close-grained, dark; takes a superior polish. Is called "ironwood," and is much used by cabinetmakers.

Acacia sub-porosa.—Stem diameter 18 inches. Wood extremely tough and elastic; used for wagon poles, tool handles, gunstocks; also for spars of coasting vessels.

Acacia koa, of the Hawaiian Islands, has a stem diameter sometimes 2 or 3 feet and is considered the best timber tree of the islands. Its wood is easy to work, hard, handsome, in great demand for furniture, boats, and building generally. It grows at an elevation of 4,000 feet above the ocean. The few remaining forests of this acacia should be protected and young plantations established to supply future needs. The tree has not yet been sufficiently tested in California.

Acacia catechu.—An even more valuable acacia is *Acacia catechu* of India. Stem diameter 2 feet. The heart wood, which is more durable than teak, is not attacked by insects. The weight of this timber is 70 pounds per cubic foot, and it is used for pestles, crushers, rollers, and all sorts of wheelwrights' work.

Besides these 25 species there are about 20 more which have not yet been tested in the United States, but whose wood is highly valued in their native countries for beauty or durability.

Timber Acacias in California.

Few of the trees which have been cut in California for wood specimens have been more than 20 years old, nor have they had diameters greater than 18 inches. Larger trees are usually so ornamental that owners dislike to cut them. But these older and larger trees would show a better quality of timber. Another thing that should be taken into consideration is that none of the timber species have been grown in California under forest conditions. The specimens in Hough's "American Woods" were grown in Alameda County as park trees. In California, *Acacia melanoxylon*, the best of the timber acacias, has made a diameter growth of 18 inches in as many years, and trees 25 years of age attain the height of 60 feet and a diameter, in some few cases, of as much as 30 inches. It is often planted as a street tree, and its ability to thrive near gas works and manufacturing establishments, where nearly every other species of tree will perish, has already been commented upon. In Shasta and Amador Counties it has been noted that this acacia is markedly resistant to the fumes of copper smelting. In Oakland there are good specimens thriving on refuse dumps and in sewage. It will stand much surplus water, alkali, and

sea salt. It is, however, not particularly frost hardy and is a tree for low, moist situations.

It has one great advantage for forest management as a timber tree, and that is its power of reproduction over large areas from root suckers. When a tree is cut down many such suckers spring up, even at a distance of from 30 to 40 feet from the parent stem, and these eventually make sturdy trees.

Acacia farnesiana was found at some of the California missions when the Americans came from the East and while it is not a large tree it should be valuable in California not only for its timber but for its perfume. *Koa* has not been sufficiently tested as yet in California, but its record in Hawaii points to great usefulness if it can be grown in commercial plantations.

Nearly all of the hardwood required by the makers of agricultural implements, wagons, carriages, railway coaches, street cars, furniture, and cabinets, or used in the interior finish of houses and boats is imported into California and becomes year by year more costly and harder to obtain. The eucalypts, because of the difficulties of seasoning and working, are not filling the bill and the acacias may be expected to help out considerably.

OTHER ECONOMIC USES OF ACACIAS.

Forage.

The acacias as legumes have value as browse for wild and domestic animals. Those which contain a large proportion of tannin are, of course, not particularly relished by animals, but since the tannin content of the different species varies greatly, there are a number which do not have this drawback. In the great African and Asiatic deserts the leaves and young shoots of acacias form the principal browse of goats and camels. In Australia certain species are of considerable value for cattle, sheep, and other live stock. Since some of the most useful forage acacias are also valuable for the fixation of drifting sands, seacoast thickets of these shrubs have a double economic value.

The Australian "scrub," locally known as "myall" and "mulga," consists of some 30 species of acacia, many of which display great drought-resisting qualities. The four best forage species, in the opinion of Dr. Maiden, are *Acacia aneura*, *A. doratoxylon*, *A. pendula*, and *A. saligna*. To these might be added *Albizzia lophantha*, still catalogued by many California nurserymen as an acacia, which is particularly well adapted to seacoast conditions.

Australian cattlemen say that saltbush (*Atriplex semibaccata*) and myall make the best beef products on that continent. The best

myalls thrive in California, especially on the sand hills, where they endure hard conditions. They would succeed on the Carissa Plains of San Luis Obispo and on the west side of the San Joaquin Valley.

In some parts of California albizzias have become naturalized, have fixed the sand, furnish forage, and still continue to extend themselves. On the sand dunes about a mile north of Morro Rock, San Luis Obispo County, *Albizzia lophantha*, self-seeded from a few dooryard trees 45 years ago, has gradually extended over about 50 acres. Each plant was browsed down to a mere green mat, which, like Thoreau's famous wild apple tree, finally become so wide across that the enemy could not bite off the central shoot, which then took heart of grace, grew high, became a tree, and seeded a new area.

The adaptability of these forage-yielding acacias and albizzia to the deserts of Mojave and Colorado can be determined, of course, only by actual trials. But it is not unreasonable to hope that several such exotic species may hold the soil and furnish forage at the same time.

In planting care should be taken to adhere closely to the few species which have been mentioned as valuable for forage, because some of the acacias are poisonous and sheep and cattle have been killed by eating the green buds.

Shelter Belts.

In all regions of brisk winds and a high rate of evaporation shelter belts are necessary to successful agriculture. In New Zealand the larger acacias are generally preferred to eucalypts for shelter-belt planting about orchards and fields; they take less from the soil, and in consequence crops can be grown closer to them. *Acacia decurrens* in its several varieties is best suited for this purpose, the seed to be sown where it is desired that the trees shall stand.

Some of the smaller acacias form excellent hedges and barriers, requiring almost no pruning and no irrigation. There are about 40 species well adapted to hedge purposes, and their local names testify to their effectiveness—"wait a bit," "dead finish," and "kangaroo thorn." *Acacia armata* is well adapted to the coast districts, and while it is graceful and seemingly harmless it constitutes an impenetrable barrier. *Acacia furox* is a South African species which forms an especially good hedge. *Acacia arabica* forms large, strong barriers. Even the thornless and very ornamental acacias can be grown close to the ground and become protective barriers as well as attractive masses of bloom in their flowering season. The fragrant *Acacia farnesiana* is often used for hedges, and *Acacia cultriformis*, *A. cyanophylla*, and *A. baileyana* are beautiful specimens for large barriers.

GUM PRODUCTS.

Several species of acacia already naturalized in America yield substances of great economic value, although in this country they are not as yet commercially utilized.

One of the most important of these substances is lac, the product of an insect (*Tachardia lacca*) of the coccid family, which feeds on the juices of many host plants and especially on certain acacias. Lac culture is a large and profitable industry in several countries and there is an increasing demand for the product. The literature of the industry is voluminous, particularly in the forest publications of the Government of India,[1] where *Acacia catechu* and *A. arabica* are cultivated as hosts for the lac insect. *Acacia farnesiana*, perhaps more valuable for perfumes, is also a lac-yielding species, as is the American *Acacia greggi* of Arizona. Since the value of the lac product on various species differs greatly, there is room for wide experimentation with those grown in America; it is generally considered, however, that *Acacia catechu*, the "kair tree" of India, is one of the best.

Gum arabic.—Any mention of vegetable gums immediately brings to mind the widely known gum arabic, derived from *Acacia arabica* as the type, but yielded also by a number of Asiatic and African desert species, all of which thrive in the warmer parts of the United States, and growing where the date palm has been successfully introduced, but requiring much less moisture. They are strongly alkali resistant and are adapted to true desert conditions. They should prove of value, therefore, in southern California, Arizona, and New Mexico. The more valuable gums used in medicine and in various arts and industries come from the *Acacia arabica*, *A. senegal*, *A. suma*, *A. verek*, *A. farnesiana*, *A. stenocarpa*, *A. gummifera*, *A. etbaica* and others. The yield is variously graded and is marked under several trade names. Single trees will flow each year from a few ounces to a few pounds of gum, and the bleeding process can be continued for many years without harm to the plant.

Many other gums are yielded by acacias, some of them highly astringent. Cutch, a product of *Acacia catechu*, is in constant demand and reaches market in several forms, as crystals found in the wood and as a gum, both pale and dark.

The cheaper grades of gum are yielded mainly by the Australian acacias and are in general use. All of the *decurrens* varieties of tanbark acacias yield commercial gums in large quantities, known specifically as wattle gums and used as a size for leather, as a substitute for isinglass, and for many other industrial purposes. *Acacia binervata*, *A. pendula*, *A. glaucescens*, *A. retinoides*, *A. homalophylla*,

[1] In this connection there is a suggestive paper on the propagation and collection of lac contributed by Mr. Lowrie, deputy forest conservator, to the Nagpur Forest Conference of 1908.

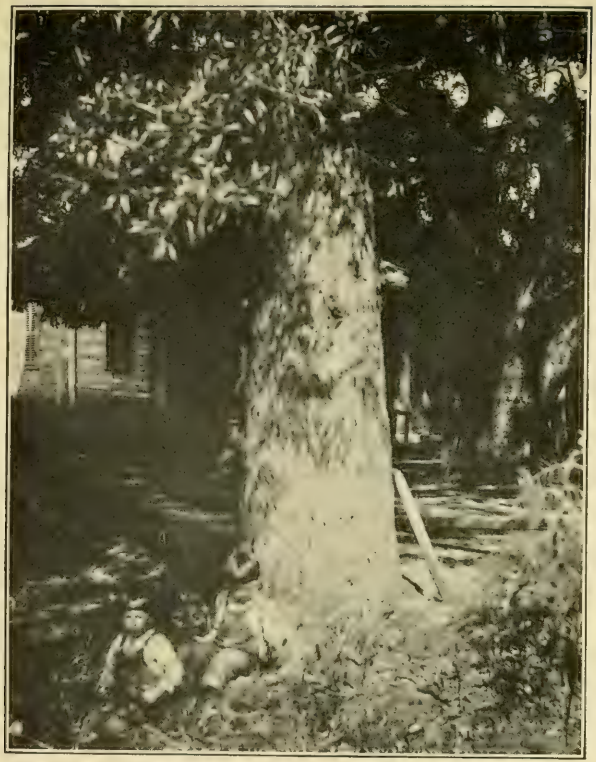


Fig. 1.—The Trunk of a 30-Year-Old Acacia melanoxylon, 3 Feet in Diameter, Niles, Cal.

Fig. 2.—Twelve-Year-Old Acacia melanoxylon, as Street Trees, Pomona, Cal.

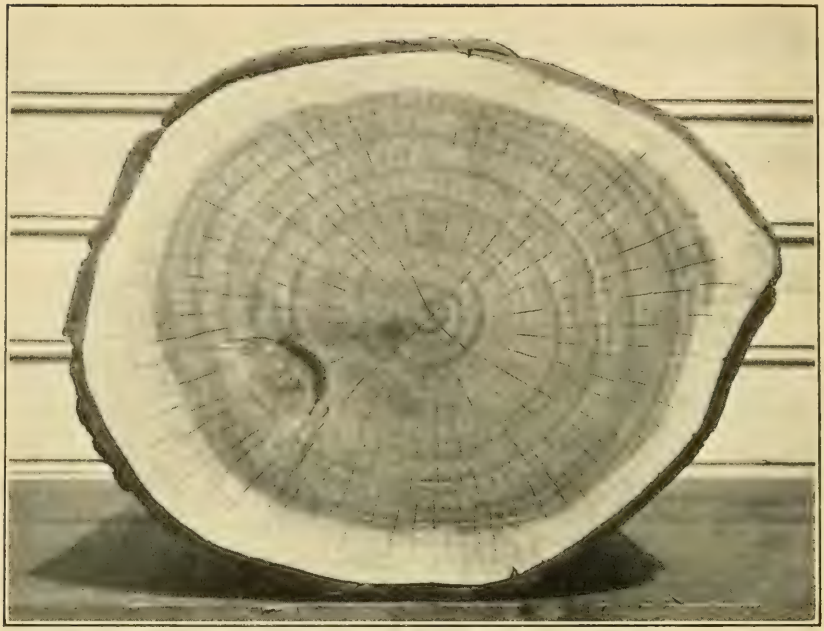


FIG. 1.—CROSS SECTION OF CALIFORNIA-GROWN ACACIA MELANOXYLON, 18 YEARS OLD; ONE OF SEVERAL TRUNKS FROM THE SAME ROOT.

FIG. 2.—FLATS OF NURSERY-GROWN ACACIAS READY TO BE SET OUT.

A. microbotya, and in fact nearly every acacia which is grown in California yield useful gum.

The best gum invariably comes from trees grown under arid conditions, and as a rule the quantity depends upon the climate and the yield increases with drought and summer heat.

Perfumes.

One species of acacia, *Acacia farnesiana*, the "cassie" of the French, takes high economic rank. It is said to have been known to Dioscorides, a Greek medical writer of the second century. Bentham thought this species was indigenous to western America from Chile to Texas and also to northern Australia; Von Mueller says: "Indigenous to south Asia westward as far as Japan. *Acacia acnifera*, endemic on the Bahamas, is very closely related to *A. farnesiana*." It is now known, however, that *A. farnesiana* is native to the high plateaus of central Africa. Mr. J. M. Purvis, chief forest officer, Nyassa Land Protectorate, writing recently from Zomba, has reported to the author that *A. farnesiana* is very common there.

Mr. H. Nehrling describes specimens in Florida 16 feet high and only 8 years old. Mr. H. Plant reports a 30-foot tree in northern Mexico. In California the largest are now from 20 to 25 feet high. Dense thickets of this acacia grow near the ruins of San Diego Mission and about other Spanish settlements. As a shrub it is not as handsome as many others, but it is perfectly adapted to large areas in America, because it is considerably hardier than the Australian species and thrives better in regions of summer rains.

The acacia-perfume industry, as carried on principally at Grasse, France, is very attractive and profitable. A full-grown tree yields about 300 pounds of flowers. The industry has been so often described that all the details of the extraction of the perfume are readily accessible. All that needs to be noted here is that a number of Australian acacias, such as *A. pycnantha* and *A. suavolens*, are used for the production of perfumes as well as *A. farnesiana*. The industry utilizes poor soils incapable of bearing grain or fruit crops, and gives light and pleasant outdoor employment to women and children.

Dyes, Medicines, Foods, and Fibers.

Several species of Australian and South American acacias furnish yellow, brown, and red dyes which are both cheap and easily obtained.

Bentham, Von Mueller, Maiden, and others have investigated the medicinal properties of acacias, but the subject, like that of acacia dyes, requires more work from specialists. It is generally known that all of the wattle acacias and many of the Asiatic and South American species are serviceably astringent. The pods and the galls

which grow on some species are locally esteemed as medicines. Salicin and saponin are yielded abundantly by several of the Australian species. The food and fiber uses of the acacias, while interesting, are commercially unimportant, and are mainly confined to the Australian species. Thozet says that the roots of *Acacia bidwillii* are edible after baking. Wattle seeds require much boiling or roasting to make them palatable, and the seeds of many species give off a most disagreeable odor when cooked. No acacia is cultivated primarily as a food plant.

PROPAGATION AND MANAGEMENT OF ACACIAS.

The conditions which govern successful acacia growing are not complex and should be readily understood by any intelligent planter. Nevertheless, there have been many failures in the propagation of acacias and large unnecessary expense. There can be no profit in growing trees of any sort for tanbark, timber, or fuel unless the expense is far below that of a nurseryman's ordinary outlay, which of course includes the cost of many transplantings and much handling of the stock. If healthy trees, well established, can not be obtained at less than half a cent a piece, the forest management of acacias will not be profitable. As a matter of fact, however, trees can be obtained at this low price.

PLANTING.

Direct Seeding.

The simple and natural way to secure an acacia plantation is to sow the seed where it is desired that the trees shall stand. This is the method followed, with local modifications, in South Africa, Algeria, India, and Australia. The method has never been adopted in California, however, except experimentally on a small scale, yet there is little reason to doubt that it will be successful in connection with a careful study of local conditions. In no other way can large plantations be cheaply established.

The seeds of acacias resemble those of common locust (*Robinia pseudacacia*), though generally smaller, and like them have a thick, hard, protective shell. Their germinative power and ability to grow rapidly is very great, and few classes of tree seeds are so well adapted to make a start and to maintain life under difficult conditions. In nearly all cases the seed has to be prepared for rapid germination. The Australian authorities say that it will sometimes remain dormant in the ground for years. Dr. Hilgard has noted an instance at Berkeley, Cal., where young acacias came up 14 years after the parent tree had been removed. Since no other tree of the same species was anywhere in the neighborhood, it is probable that the seed had lain all that time without germinating. Especially in light soils and

in seasons of scanty rainfall it seems wise, therefore, to assist the germinating process. Usually this is done by placing seed in a vessel and pouring over it boiling water, leaving the seed to soak and swell for from 24 to 48 hours. Seed may even be boiled for some minutes without injury.

Seed may be prepared for germination by dry as well as by moist heat; in other words, it may be more or less roasted. After every fire in the Australian "bush" perfect forests of young wattles spring up. Some planters burn brushwood to embers and then mix the acacia seed with ashes and dying coals, leaving it for several days. Sometimes, too, seed may be shaken in a frying pan over the fire.

In California it has been observed that acacia seedlings come up abundantly where piles of acacia brush have been burned, usually in rings several inches wide around each brush pile. Where the short, dry grass and weeds under acacia groves have been burned reproduction has been assisted both in quantity and distribution.

The following tests, reported by Mr. J. E. Brown (Australia) show the effects of various treatments of the seed:

Acacia pycnantha.—Five parcels of seed saturated with water at temperatures of 150° F., 170°, 190°, 200°, and 212°, respectively. All germinated well in three weeks. Four parcels of seed boiled for 1, 3, 5, and 7 minutes, respectively. All germinated in 18 days.

Acacia saligna.—Seed saturated in boiling water germinated in one week.

Acacia decurrens.—Seed saturated with boiling water and then swelled in wet sand. Germinated in two weeks.

Tests made for this report on California grown seed are as follows:

Acacia pycnantha.—Seed boiled for 5 minutes germinated 30 per cent in 4 days, with nearly all of the remaining seed still sound at the end of 11 days.

Acacia melanoxylon.—Seed boiled 2 minutes germinated 20 per cent at the end of 11 days. Boiled 7 minutes germinated 6 per cent. Much of the seed, however, was sound and simply required more time to sprout.

Acacia cyanophylla.—Seed boiled 2 minutes germinated 70 per cent; boiled 5 minutes germinated 64 per cent; boiled 10 minutes germinated 4 per cent.

After the seed has been heated it may be mixed with damp sand and left until sprouting before it is sown. The objections to this process are that it can not then be drilled and the seedling is more likely to succumb in case of protracted dry weather. Mr. Perrin, state conservator of forests, Victoria, mixes half a bushel of sand with each pound of seed and broadcasts. Some planters sow the seed on top of plowed ground; others cover with a harrow. Where there is a loose soil sheep may be driven over the tract to tread in the seed. Often barley is sown with the acacia seed to serve as a shelter. It is said that some successful plantations have been started in the scrub in Australia. Possibly there are places in California where the chaparral could be broadcasted with profit, but as a rule clearing is necessary. It is claimed that the seed of tanbark acacias is hardly

ever subject to depredations by rodents, and that gophers will not gnaw their roots.

After a plantation is established the natural way to secure reproduction is to depend upon self-sown seedlings. It is likely, however, that these may come up irregularly, and that the use of the drill or transplants may be necessary to secure a uniform stand. The mere fact that acacias become naturalized and spread over waste places in parts of India, Africa, Algeria, California, and the Southwest does not necessarily imply that well-stocked groves can be produced invariably without aiding nature.

The method of planting known in the Forest Service as seed spotting, equivalent to planting in hills, has several advantages over broadcasting. It saves a great deal of seed; it enables the planter to pick out the best spots and to prepare them with some care; and it greatly reduces the cost of subsequent thinnings. In many cases land may be so well prepared that seed could be drilled in or sown by hand in rows. Thorough cultivation of the ground is of course desirable, yet excellent plantations have been established with less cost of time and labor. For example, at Mount Benson, South Australia, where the soil is very poor—the mere white sand of the "fern hills"—double furrows 8 feet apart were struck out. Seed which had been soaked in boiling water was drilled in and covered with a harrow, 1 pound to the acre. In some places it would be practicable to attach drill and harrow to the plow and complete the whole planting operation at one time. One man and a team can plant 8 acres a day.

Use of Nursery Stock.

Nursery methods are too expensive for the forester except to supplement field sowing. They involve skilled labor and the use of considerable material such as seed boxes and flats and pots, either of paper or clay. In India sections of bamboo are used for the plants, which are set in the ground as soon as the seedling is ready for the field. In Australia stems of the reed *Arundo donax* have been used at a cost of $1.25 a thousand tubes, this price including the cutting of the reeds, filling the sections with earth, and setting out the plants.

California nurserymen sow their acacia seed beds in June, July, and August, and the plants are ready to be transplanted to pots or to be set out the following spring. The seed-bed method entails a heavy loss, and boxes, flats, or trays are usually preferable and cheaper. These flats are generally 4 inches deep and contain 2 or 3 square feet. Each one will hold from 100 to 200 plants of transplant size. Generally they are sheltered from sun and wind by lath houses, by brush, or by being placed under large trees. One laborer can care for many thousand of these small acacias in the flats, which

need only to be watered every evening and to be thinned so that the plants will stand an inch or so apart.

SPROUTING AND LAYERING.

All the tanbark wattles sprout readily from the stump, and this method of crop reproduction is especially valuable when acacias are grown for firewood. The sand-reclaiming acacias will root even from the recumbent stems. This helps them to spread over the ground. This natural layering process can be aided by slashing the lower branches, bending them down, and covering the gash with earth. *A. saligna* and *A. longifolia* thus treated spread almost as well as willows.

GENERAL CONCLUSIONS.

The most important fact derived from an economic study of acacias in California is that after some fifty years many species of acacia have proven themselves to be entirely at home over large areas, and have in fact become naturalized. They are worth the careful investigation of tree planters and foresters, for they fill a place which is not occupied by any other group of exotic trees. Since many of them make only slight requirements on moisture and soil, their cultivation need not interfere with that of other exotic trees for special products, such as the Japanese chestnut, cork oak, camphor tree, date palm, eucalypts, algaroba or carob, and maritime pine.

The unique field occupied by acacia tanbark and by some other products, especially the gums, and the usefulness of the best acacia woods would seem to justify the general conclusion that plantations properly located and managed are as likely to prosper in America as in other countries. But before extensive commercial operations are decided upon there is need for more complete and painstaking work upon the acacias—their growth and their products—the study to be based upon American-grown trees. As yet the rates of growth and the yields of various species on different soils, especially under plantation conditions, are not definitely determined. Unless such preliminary scientific investigation is undertaken and its evidence accepted, it is likely that industries based upon acacias may be exploited too hastily, and, therefore, present failures will give setbacks such as have resulted where the culture of any particular tree has become a fad. These failures are likely to do much to deter properly qualified persons from entering upon an industry which should ultimately become established on solid foundations.

So far, acacias have been planted in the United States simply as ornamentals, and the information secured from a study of these specimens has been chiefly cultural. They have proved that the

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best acacias thrive in California, and that they will grow on poor and arid soils, where there is little or no frost. Beyond this there is not much information, and some misinformation. For example, they are commonly bracketed with the eucalypts in the minds of many persons, simply because the eucalypts and most of the acacias come from Australia. The place occupied by the acacias, however, is as distinct from that of the eucalypts as both are from oaks or from conifers.

To successfully develop commercial plantations of acacias in the United States, at least three problems will need to be solved. First, the behavior of the trees under close-planted commercial conditions must be known, and this can be learned only from experimental plantations. Second, the various labor-saving economies will have to be studied, and methods standardized, because American economic conditions are markedly different from those of Natal, Hawaii, the Transvaal, and Australia. Third, and probably most important and difficult, will be the problem of marketing the products in competition with those produced cheaply abroad.

It will probably be very easy for American planters to duplicate the working plans of acacia growers elsewhere, or even to improve upon them as far as American conditions will induce changes in details. Successful acacia culture depends primarily upon good farm practice. Hard-working, practical men, even without special training in forestry, have created great plantations. It is likely that the same thing will occur in this country. At the same time the true spirit of scientific investigation, the power of observing and drawing correct conclusions are essential to the development of this industry along new lines.

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